

(19)



(11)

EP 3 301 330 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
04.04.2018 Bulletin 2018/14

(51) Int Cl.:
F16H 48/42 ^(2012.01) **F16H 57/00** ^(2012.01)
F16C 3/02 ^(2006.01)

(21) Application number: **17188921.5**

(22) Date of filing: **01.09.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(72) Inventors:
• **Zhang, Jack**
Yushan Town, Kunshan City, Jiangsu Province (CN)
• **Zhang, Richard**
Suzhou City, Jiangsu Province (CN)
• **Fu, Aaron**
Suzhou City, Jiangsu Province (CN)

(30) Priority: **29.09.2016 CN 201610862296**

(74) Representative: **Fenner, Seraina**
Georg Fischer AG
Amsler-Laffon-Strasse 9
8201 Schaffhausen (CH)

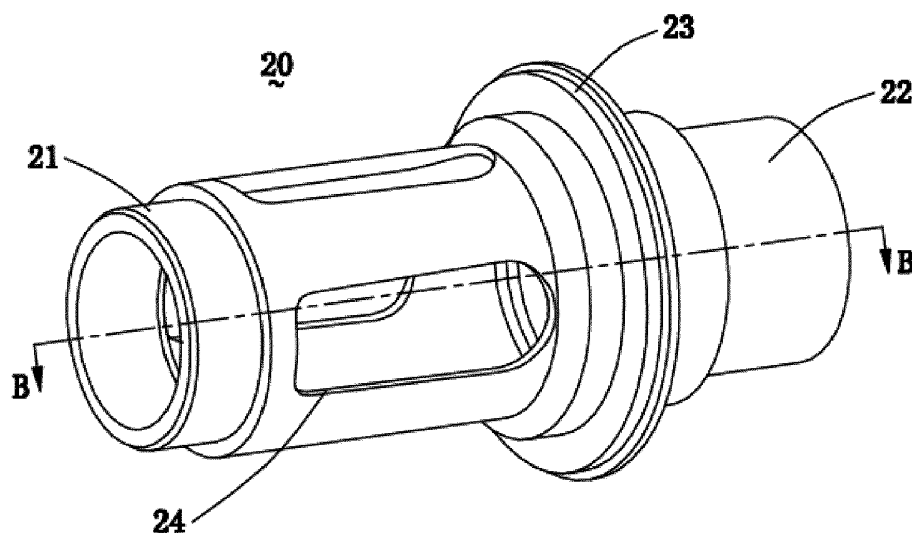
(71) Applicant: **Georg Fischer Automotive (Kunshan) Co Ltd.**
Jiangsu 215300 (CN)

(54) **POWER TAKE-OFF UNIT RING GEAR SHAFT, MANUFACTURING METHOD THEREOF AND APPARATUS COMPRISING THE SAME**

(57) The invention relates to a power take-off unit ring gear shaft, a method of manufacturing such a power take-off unit ring gear shaft and an apparatus comprising the power take-off unit ring gear shaft. The ring gear shaft of the invention has an annular shaft wall which surrounds a hollow inner cavity that extends throughout the entire gear shaft in an axial direction, and hollow portions are

formed in the shaft wall. The invention realizes a lightweight product, helps to realize a lightweight entire vehicle, and meanwhile reduces machining areas, thus improving production efficiency of machining, reducing production cost of product, reducing labor intensity and improving productivity.

[Figure 4]



EP 3 301 330 A1

Description

FIELD OF THE INVENTION

[0001] The invention relates to the technical field of manufacturing vehicle elements and components; specifically, the invention relates to a power take-off unit ring gear shaft of vehicle. The invention further relates to a method of manufacturing such a power take-off unit ring gear shaft and an apparatus comprising the power take-off unit ring gear shaft.

BACKGROUND OF THE INVENTION

[0002] The power take-off unit (PTU) is used in a vehicle (e.g., commercial Vehicle passenger vehicle) to output the power to the outside. For example, in a four-wheel drive vehicle, the PTU is connected to a front engine and transmission so as to transmit the torque to a rear axle.

[0003] The PTU ring gear shaft is one of the important components of the PTU. Fig. 1 shows a schematic view of the PTU ring gear shaft in the prior art, wherein a right side end 1 is the input end which is connected to the transmission case via a coupling sleeve, a bearing is mounted to a left side end 2 so as to be fitted with the PTU case, and an intermediate flange 3 is connected to a bevel gear so as to transmit the power to the rear output shaft. In the prior art, the PTU ring gear shaft is designed to be a solid circular ring, which does not meet a lightweight requirement.

[0004] In the prior art, PTU ring gear shafts are mostly manufactured using machining methods. Firstly, a suitable tubing material or bar material is selected; then, the inner and outer sides of the material are cut and formed. Such a way of manufacturing has a high cost, a low utilization rate of material and a low production efficiency, thus making it not suitable for massive production. More importantly, this manufacturing method destroys metal streamline, thus greatly reducing the performances of elements.

[0005] In the prior art, there is also a method for manufacturing PTU ring gear shaft, in which a blank is produced by firstly cold-pressing precision molding and forging, and then precision machining. This method also has the defect of low utilization rate of material. Meanwhile, whether cold-pressing molding or forging, a high requirement is put on the mold; moreover, the mold has a very high cost and the service life of it is also not long, and meanwhile a large-tonnage press machine is required. The elements produced by cold-pressing and by forging have a poor plasticity and impact ductility as well as a large residual stress, which will result in a deformation of elements and a reduction in the resistance to stress corrosion.

SUMMARY OF THE INVENTION

[0006] The object of the invention is to provide a power

take-off unit ring gear shaft and a method of manufacturing the same which can overcome the above defects in the prior art.

[0007] Further, the object of the invention is also to provide an apparatus which comprises the power take-off unit ring gear shaft.

[0008] In order to achieve the above objects, a first aspect of the invention provides a power take-off unit ring gear shaft, wherein the gear shaft has an annular shaft wall which surrounds a hollow inner cavity that extends throughout the entire gear shaft in an axial direction, and hollow portions are formed in the shaft wall.

[0009] Optionally, in the above described gear shaft, the hollow portions are evenly distributed in the circumferential direction in the shaft wall.

[0010] Optionally, in the above described gear shaft, the gear shaft has a support end that is adapted to be mounted to a power take-off unit case via a bearing, and an intermediate flange that is adapted to fix a bevel gear, wherein the hollow portions are located between the support end and the intermediate flange.

[0011] Optionally, in the above described gear shaft, the inner cavity is a step-like mold cavity.

[0012] Optionally, in the above described gear shaft, the gear shaft has an input end that is opposite to the support end, and the thickness of the shaft wall at the input end is larger than that of the shaft wall at the side of the support end.

[0013] Optionally, in the above described gear shaft, the gear shaft is made of spheroidal graphite iron material.

[0014] Optionally, in the above described gear shaft, the spheroidal graphite iron material is QT700-10.

[0015] In order to achieve the above objects, a second aspect of the invention provides an apparatus comprising any of the above described gear shafts according to the first aspect.

[0016] Optionally, the above described apparatus is a vehicle power take-off unit or a vehicle.

[0017] In order to achieve the above objects, a third aspect of the invention provides a method for manufacturing any of the above described gear shafts according to the first aspect, wherein the method comprises:

- step A: using a sand mold casting process to cast a blank of the gear shaft, wherein the blank has the inner cavity and the hollow portions; and
- step B: machining an outer cavity of the blank so as to form the gear shaft.

[0018] The invention realizes a lightweight product, helps to realize a lightweight entire vehicle, and meanwhile reduces machining areas, thus improving production efficiency of machining, reducing production cost of product, reducing labor intensity and improving productivity.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

[0019] The disclosure of the invention will become more apparent with reference to the accompanying drawings. It should be understood that the drawings are merely provided for illustrative purpose, and are not intended to limit the scope of protection of the invention, wherein:

Fig. 1 is a schematic view of the vehicle power take-off unit ring gear shaft in the prior art;

Fig. 2 is a schematic perspective view of the ring gear shaft according to an embodiment of the invention;

Fig. 3 is a A-A sectional view of the ring gear shaft in Fig. 2;

Fig. 4 is a schematic perspective view of the ring gear shaft according to another embodiment of the invention;

Fig. 5 is a B-B sectional view of the ring gear shaft in Fig. 4; and

Fig. 6 shows a schematic state in which the ring gear shaft in Fig. 4 is on a casting core.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Specific embodiments of the invention will be described below with reference to the accompanying drawings, in which identical or similar technical features are denoted by identical reference signs.

First embodiment

[0021] Fig. 2 is a schematic perspective view of the ring gear shaft according to a first embodiment of the invention, and Fig. 3 is a A-A sectional view of the ring gear shaft.

[0022] As shown, the power take-off unit ring gear shaft 10 has an annular shaft wall, the cross sections of which at various axial positions are circular rings having identical or different sizes. The shaft wall can comprise a support end 11, an input end 12, an intermediate flange 13 or the like that are integrally formed with the shaft wall, and the ways of forming these components comprise but are not limited to machining, press molding, forging and/or casting, etc. As can be seen from the drawings, the shaft wall surrounds a hollow inner cavity 15 which extends throughout the entire gear shaft 10 in an axial direction, and additional shafts may also extend inside the cavity. Two hollow portions 14 are illustratively formed in the shaft wall.

[0023] The support end 11 of the gear shaft 10 is adapted to be mounted to a power take-off unit case on the vehicle via a bearing, whereby the gear shaft 10 can rotate inside the power take-off unit. An end of the gear shaft 10 which is opposite to the support end 11 is the input end 12 which is used for receiving power from the

transmission box. The intermediate flange 13 which is adapted to fix a bevel gear (not shown) is located between the support end 11 and the input end 12. The bevel gear can output the received power to a rear axle of the vehicle. It can be seen that power is transmitted in a sequence of the transmission box- the input end 12- the intermediate flange 13- the bevel gear- the vehicle rear axle, and the support end 11 serves to support and position and does not bear a very high torque.

[0024] According to the illustrated embodiment, hollow portions 14 having an oblong shape can be formed in the shaft wall. The hollow portions 14 are preferably evenly distributed in the circumferential direction in the shaft wall. It can be conceived that under the premise the performance requirements on the ring gear shaft are met, providing these hollow portions in the shaft wall is advantageous for structure optimization, thus realizing a lightweight product. Since a very high torque is not borne between the support end 11 and the intermediate flange 13, the hollow portions 14 are preferably located between the support end and the intermediate flange. If permitted by performance, hollow portions may be also formed at the input end 12 or other positions. It can be understood that in other embodiments, in case that the performance of the ring gear shaft 10 is ensured, the number, shape and arrangement of the hollow portions can be changed. Those skilled in the art will understand that whether the performance design of product meets requirements of working conditions can be verified by finite element calculation.

[0025] It can be seen from Fig. 3 that in this embodiment, the inner cavity 15 of the shaft wall of the ring gear shaft 10 is of a smooth column shape, and the thicknesses of the shaft wall at the support end 11 and the input end 12 are the same. The inner cavity of the shaft wall can be formed by casting or by machining (without being limited thereto), etc., The ring gear shaft 10 in this embodiment can be formed by cutting out the hollow portions 14 in a prior art ring gear shaft having a solid circular ring structure.

[0026] More preferably, the ring gear shaft 10 in this embodiment can be manufactured by casting using a spheroidal graphite iron material. For example, the spheroidal graphite iron material can be QT700-10. Using this spheroidal graphite iron material greatly improves the reliability of casting the ring gear shaft. It can be known that in this casting method, a blank of the ring gear shaft can be firstly cast using a sand mold casting process so that the blank has an inner cavity and hollow portions, and then the outer cavity of the blank can be machined so that the gear shaft is formed.

Second embodiment

[0027] Fig. 4 is a schematic perspective view of the ring gear shaft according to a second embodiment of the invention, and Fig. 5 is a B-B sectional view of the ring gear shaft.

[0028] As shown, the power take-off unit ring gear shaft 20 also has an annular shaft wall, the cross sections of which at various axial positions are circular rings. The shaft wall can comprise a support end 21, an input end 22, an intermediate flange 23 or the like that are integrally formed with the shaft wall, and the ways of forming these components comprise but are not limited to machining, press molding, forging and/or casting, etc. As can be seen from the drawings, the shaft wall surrounds a hollow inner cavity which extends throughout the entire gear shaft 20 in an axial direction, and additional shafts may also extend inside the cavity. Four hollow portions 24 are illustratively formed in the shaft wall.

[0029] The support end 21 of the gear shaft 20 is adapted to be mounted to a power take-off unit case on the vehicle via a bearing, whereby the gear shaft 20 can rotate inside the power take-off unit. An end of the gear shaft 20 which is opposite to the support end 21 is the input end 22 which is used for receiving power from the transmission box. The intermediate flange 23 which is adapted to fix a bevel gear (not shown) is located between the support end 21 and the input end 22. The bevel gear can output the received power to a rear axle of the vehicle. It can be seen that power is transmitted in a sequence of the transmission box- the input end 22- the intermediate flange 23- the bevel gear- the vehicle rear axle, and the support end 21 serves to support and position and does not bear a very high torque.

[0030] According to the illustrated embodiment, hollow portions 24 having an oblong shape can be formed in the shaft wall. The hollow portions 24 are preferably evenly distributed in the circumferential direction in the shaft wall. It can be conceived that under the premise the performance requirements on the ring gear shaft are met, providing these hollow portions in the shaft wall is advantageous for structure optimization, thus realizing a lightweight product. Since a very high torque is not borne between the support end 21 and the intermediate flange 23, the hollow portions 14 are preferably located between the support end and the intermediate flange. If permitted by performance, hollow portions may be also formed at the input end 22 or other positions. It can be understood that in other embodiments, in case that the performance of the ring gear shaft 20 is ensured, the number, shape and arrangement of the hollow portions can be changed. Those skilled in the art will understand that whether the performance design of product meets requirements of working conditions can be verified by finite element calculation.

[0031] It can be seen from Fig. 5 that in this embodiment, the inner cavity of the shaft wall of the ring gear shaft 20 is a step-like mold cavity, and the thicknesses of the shaft wall at the support end 21 and the input end 22 are different. Specifically, considering that the input end 22 of the gear shaft 20 has to provide torque transmission, the thickness of the shaft wall at the input end 25b can be larger than that of the shaft wall at the support end 25a. The step-like structure can make the structure

lightweight, and meanwhile can increase the space of the inner cavity of the shaft, thus increasing the gap with an inner shaft. The inner cavity structure of the shaft wall can be formed by casting or machining (without being limited thereto), etc. Preferably, the structure can be formed directly by a sand core during casting, and can meet the requirement of minimum gap with the inner shaft without the need for subsequent machining.

[0032] More preferably, the ring gear shaft 20 in this embodiment can be manufactured by casting using a spheroidal graphite iron material. For example, the spheroidal graphite iron material can be QT700-10. Using this spheroidal graphite iron material greatly improves the reliability of casting the ring gear shaft. It can be known that in this casting method, a blank of the ring gear shaft can be firstly cast using a sand mold casting process so that the blank has an inner cavity and hollow portions, and then the outer cavity of the blank can be machined so that the gear shaft is formed.

[0033] Fig. 6 shows a schematic state in which the ring gear shaft in Figs. 4 and 5 is on a casting core. The solid lines show the casting core 30, and the dashed lines show the ring gear shaft 20.

[0034] It can be seen that in this sand molding casting process, a main body part of the core forms an inner cavity of the blank of the ring gear shaft, and a radial extension 31 from the main body of the core forms the hollow portion of the blank of the ring gear shaft. After the blank of the ring gear shaft is removed from the core, the outer cavity of the blank is machined so that the gear shaft is formed. The method of manufacturing has a very high production efficiency and a low manufacture cost, thus making it suitable for massive production. Meanwhile, the inner cavity portion and the hollow portions can be formed by one-step casting using a core. In this way, the inner cavity and the hollow portions can be formed without the need for machining, thus improving the production efficiency of machining at a later stage and reducing production cost; sand core casting has a higher accuracy than forging, and can preserve a smaller machining allowance, thus greatly improving the production efficiency of machining and reducing the cost of finished product.

[0035] Through the above detailed description of the ring gear shaft or the like, those skilled in the art will conceive an apparatus equipped with the ring gear shaft, which for example comprises but is not limited to a vehicle power take-off unit or a vehicle.

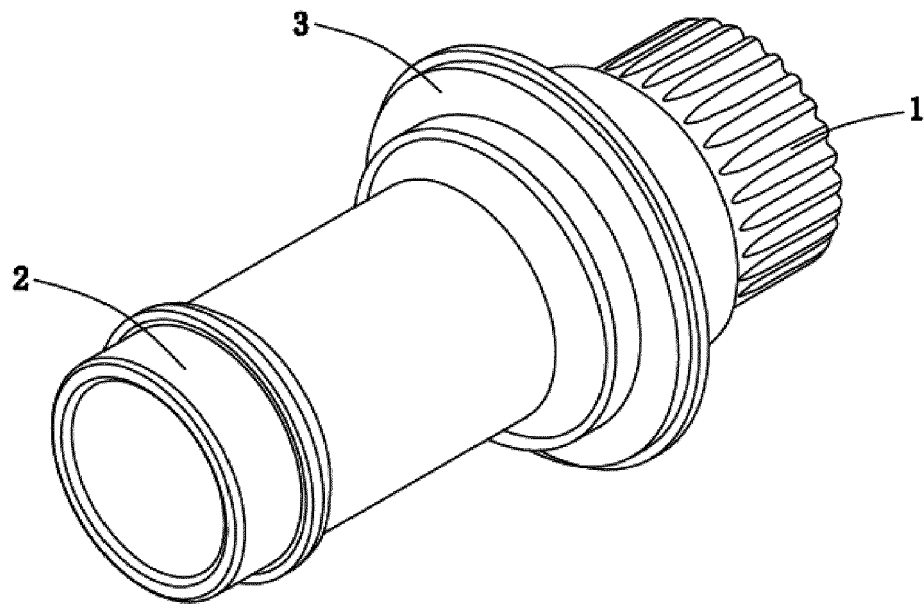
[0036] The technical scope of the invention is not merely limited to the above description, and those skilled in the art can make various variations and modifications to the above described embodiments without departing from the technical concept of the invention, and all these variations and modifications should fall into the scope of the invention.

Claims

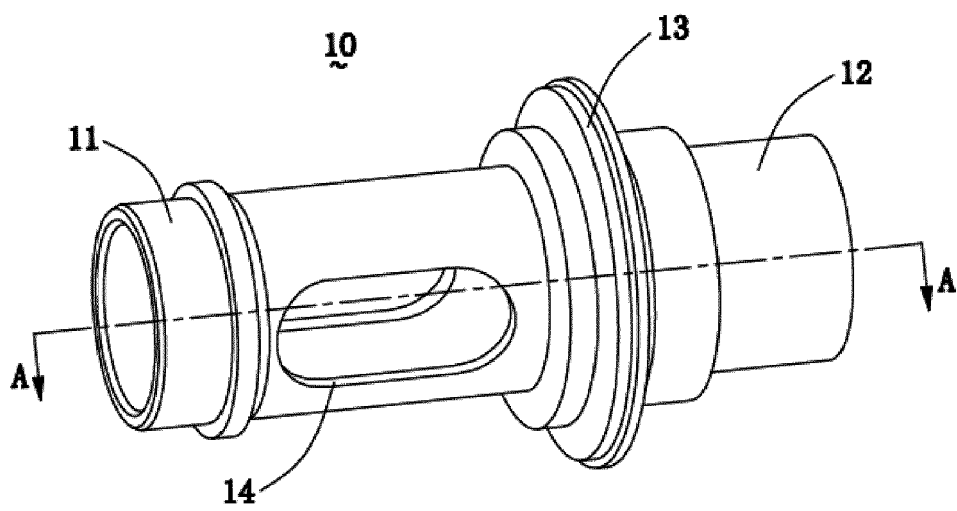
1. A power take-off unit ring gear shaft, **characterized in that** the gear shaft has an annular shaft wall which surrounds a hollow inner cavity that extends throughout the entire gear shaft in an axial direction, and hollow portions are formed in the shaft wall. 5
2. The gear shaft according to claim 1, wherein the hollow portions are evenly distributed in the circumferential direction in the shaft wall. 10
3. The gear shaft according to claim 1 or 2, wherein the gear shaft has a support end that is adapted to be mounted to a power take-off unit case via a bearing, and an intermediate flange that is adapted to fix a bevel gear, wherein the hollow portions are located between the support end and the intermediate flange. 15
20
4. The gear shaft according to claim 1, wherein the inner cavity is a step-like mold cavity.
5. The gear shaft according to claim 4, wherein the gear shaft has an input end that is opposite to the support end, and the thickness of the shaft wall at the input end is larger than that of the shaft wall at the side of the support end. 25
6. The gear shaft according to claim 1, wherein the gear shaft is made of spheroidal graphite iron material. 30
7. The gear shaft according to claim 6, wherein the spheroidal graphite iron material is QT700-10. 35
8. An apparatus comprising a gear shaft according to any of claims 1 to 7.
9. The apparatus according to claim 8, wherein the apparatus is a vehicle power take-off unit or a vehicle. 40
10. A method for manufacturing a gear shaft according to any of claims 1 to 7, wherein the method comprises: 45
 - step A: using a sand mold casting process to cast a blank of the gear shaft, wherein the blank has the inner cavity and the hollow portions; and
 - step B: machining an outer cavity of the blank so as to form the gear shaft. 50

55

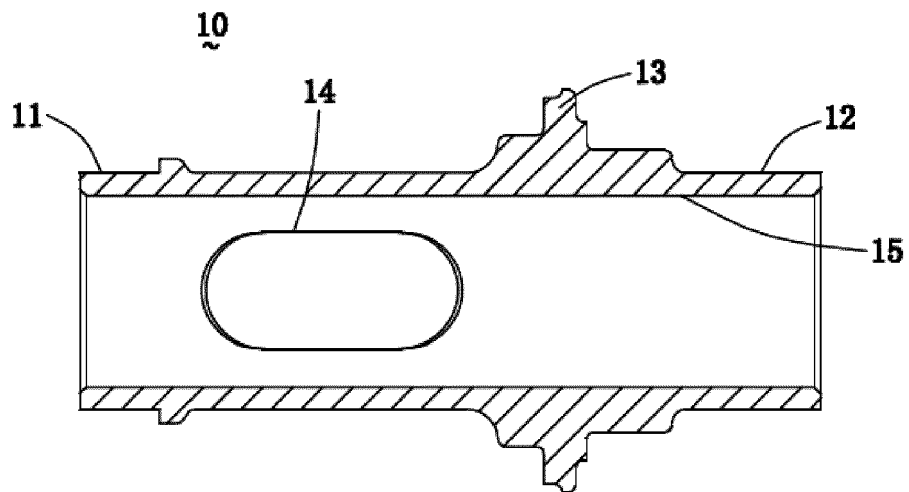
[Figure 1]



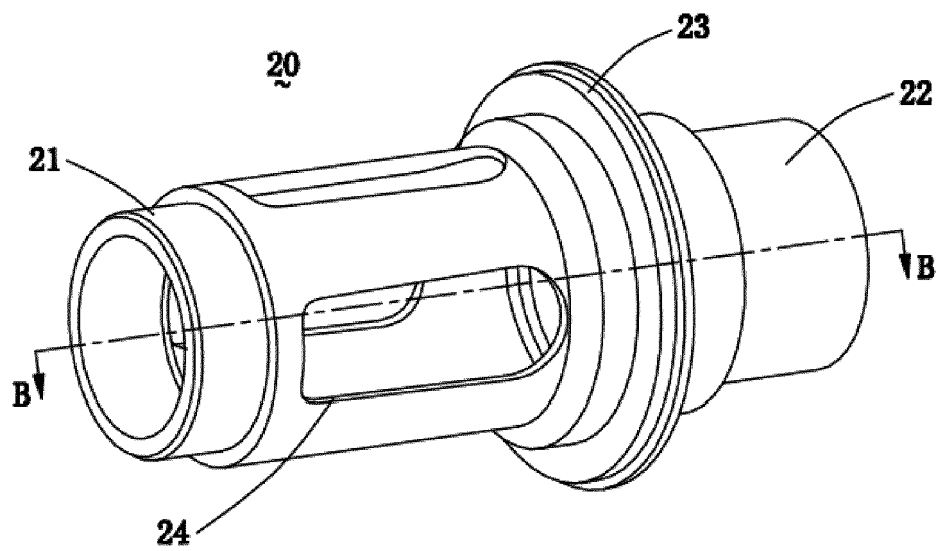
[Figure 2]



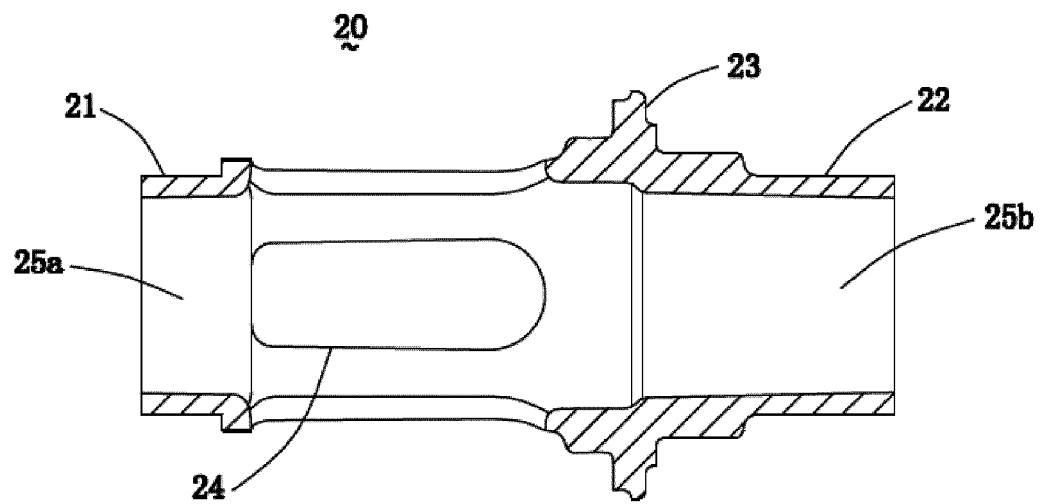
[Figure 3]



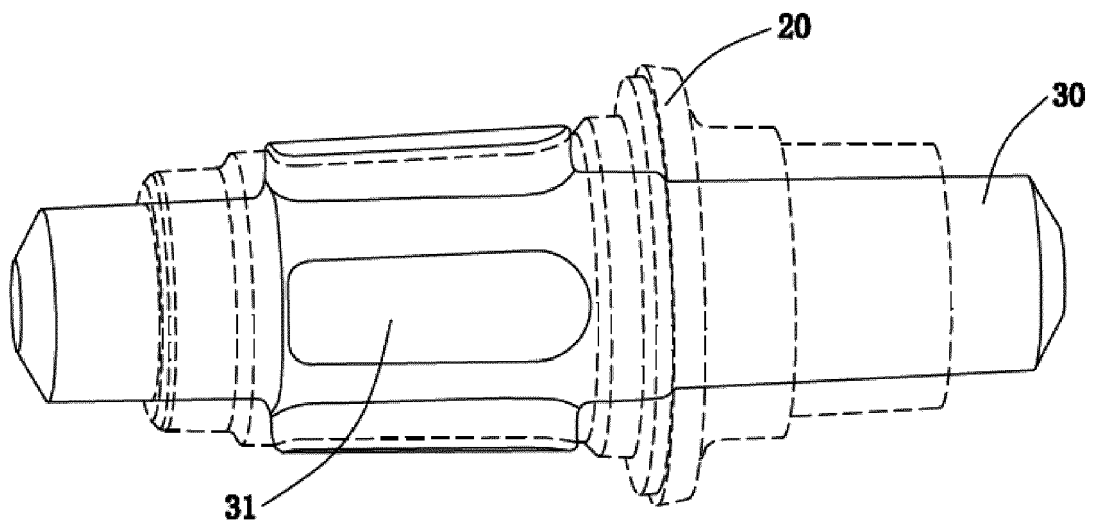
[Figure 4]



[Figure 5]



[Figure 6]





EUROPEAN SEARCH REPORT

Application Number
EP 17 18 8921

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 496 333 A (CLEVELAND DONALD C [US]) 29 January 1985 (1985-01-29)	1,8	INV. F16H48/42 F16H57/00 F16C3/02
Y	* claim 1; figures 1-4 *	3-6,9,10	
Y	US 2004/226170 A1 (PRUCHER BRYAN P [US]) 18 November 2004 (2004-11-18) * figures 4a,4b *	3,5,9	
Y	US 2003/075301 A1 (KIMBROUGH LARRY C [US] ET AL) 24 April 2003 (2003-04-24) * paragraphs [0035], [0037], [0038]; figure 1 *	4,6,10	
A	CN 204 657 409 U (KUNSHAN QUANSHUN ALUMINUM FORGING CO LTD) 23 September 2015 (2015-09-23) * the whole document *	1-10	
A	US 2013/333503 A1 (PEURA BRENT [US] ET AL) 19 December 2013 (2013-12-19) * the whole document *	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			F16H F16C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 14 February 2018	Examiner Hassiotis, Vasilis
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 18 8921

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-02-2018

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4496333 A	29-01-1985	NONE	
US 2004226170 A1	18-11-2004	DE 112005000616 T5 US 2004226170 A1 WO 2005089364 A2	01-02-2007 18-11-2004 29-09-2005
US 2003075301 A1	24-04-2003	NONE	
CN 204657409 U	23-09-2015	NONE	
US 2013333503 A1	19-12-2013	US 2013333503 A1 US 2016243937 A1	19-12-2013 25-08-2016

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82